Does Investment React to Monetary Policy? Evidence from U.S. Non-financial Firms

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Abstract

The purpose of this thesis is to provide empirical evidence on the effectiveness of the U.S. monetary policy in stimulating corporate investment over the period 2000-2015. I assess the effectiveness through the combination of Tobin's q effect and the balance-sheet channel of monetary policy transmission mechanism, considering the sample of U.S. non-financial companies included into S&P 1500 Composite Index. Particular interest of this work is whether changes in leverage driven by shifts in monetary regime affect firms' investment decisions. In addition to traditional effective federal funds rate, I implement Wu-Xia shadow federal rate suited for the analysis of unconventional monetary policy mechanisms in zero lower bound framework. Applying Arellano-Bond estimator in dynamic panel model I show that change in the leverage driven by the shift in monetary policy regime is a statistically significant determinant of firms' investment, which in addition reacts to changes in ratios of sales to capital and Tobin's q. Easing monetary actions during zero lower bound represented by Wu-Xia shadow rate appears to be positively affecting firms' investment.

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I. Introduction

With the increasing attention to monetary policy as a tool for stimulating economic growth, particularly in post-crisis period, arguments about possible channels of the monetary transmission mechanism, through which changes in the nominal money stock or the short-term nominal interest rate can have an impact on real variables such as investment, output and employment, became a point of clashing for policymakers and theoretical economists.

The basics of the theory underlying monetary transmission mechanisms is having roots practically from the beginning of the establishment of the economic theory in its contemporary understanding. However, intensive development of the separated research line devoted to channels of monetary policy started only with increasing independence of central banks and clearing up their policy mandates. Since the 1990s, the list of contributors to this direction of research has been expanding with Mishkin, Bernanke, Gertler, Taylor, Blinder, Eichenbaum, Romer and Romer, among others, who had been already concentrating on monetarism-related disputes following the fundamental work of monetarism by Friedman and Schwartz of 1963.

Investment, as one of the most important components of economic growth, has been considered through the scope of traditional transition mechanisms of monetary transmission. Comprehensive review of these channels, conducted by Mishkin in 1995, broadly separates four operative ways: through interest rate, exchange rate, asset prices, and credit. The first three channels, including Tobin's *q* effect, or an equity price channel, accompanied by house, lend, and wealth channels, - lately have been known as neoclassical channels. Credit channel, including balance-sheet and bank-lending transmissions, – mostly constitutes the room left for non-neoclassical school-related theories.

In 1996 Bernanke and Gertler already noted the incompleteness of explanations lying under the interest rate-sensitive components of aggregate spending, and that some of the channels are not more than enhancement mechanisms that cannot be practically isolated. These issues were evidenced by Mishkin as well, when he claimed that the oversimplification of non-credit channels was serving as a driving force to behind more sophisticated explanations.

Since 1996 possible new separate channels have been identified, such as risk-taking channel, and different combinations of initial channels have been considered and empirically proven to work by monetary economists. Nevertheless, sustainability of inclusion of a particular channel into policy-oriented models has been characterized as discriminative. As lately Boivin, Kiley and Mishkin (2010) claim, non-neoclassical connection mechanisms have remained to be used even in modern dynamic equilibrium models, while non-neoclassical channels have not received so much attention.

One of the most significant problems continuously being faced by monetary researchers is the separation of different channels, as the effects of monetary policy are usually considered on an aggregate economy level. Furthermore, Boivin, Kiley and Mishkin (2010) show that monetary innovations have less significant effects on real activity and inflation than before 1980s, in the same time stating that monetary policy changes remained to be a determinant of expectations with leaving even less room for private-level changes that are not driven by policy decisions. The goal of this thesis is to estimate to which extent companies' investment decisions are predestined by monetary policy decisions, particularly through managing the companies' leverage as reaction to policy changes.

As far as the concentration of macro and aggregate level analysis has been prevailing feature of policy-oriented research, it has limited policymakers with the set of possible signals

serving as a ground for a change in monetary course. Thus, usage of the expansive measures is justified until an economy starts to provide the monetary authority with real evidence on improvement in the particular economy's area, be it a labor market, industrial production, or show signs of overheating of financial markets, etc. From the other side, the choice is limited by a commitment to a monetary rule, depending on a central bank's mandate.

Reactions of the monetary policy-sensitive components of economic growth are considered to be determined implicitly based on the structural characteristics of particular economy, which makes empirical analysis contributing only to understanding of the economy's 'black-box'[1] posteriori. Nevertheless, maximizing and accelerating monetary policy impact is primary a question of stronger and more sustainable reactions of a particular channel to the use of a particular policy instrument. Empirical findings should provide policymakers with a vision of balancing the effects and avoiding overstimulating, thus overexposing to financial and credit risks emerging in excessively and uncontrollably reactive sectors. Particular importance should be assigned to those sectors, whose performance is determined by structure of capital with a tendency to show stronger operation during easing stages of the monetary cycle.

This thesis aims to contribute to the partial opening of the "black-box" by estimating firm- and industry-level reactions to the changes of monetary policy. I examine the question whether firm's investment is determined by the course of monetary authorities, with particular interest on adjustment of firms' leverage to the interest rate shock. Micro-level panel data analysis and dynamic modeling approach used in the thesis constitute the empirical novelty added to the existing research on the topic, while the introduction of adjustment costs and control for different

[1] Bernanke, B. S., & Gertler, M. (1995) uses the metaphor of "black box" to describe how the empirical analysis of monetary policy treated monetary mechanisms.

monetary indicators suited for the unconventional monetary policy tools widely used in post financial crisis period, is aimed to enrich the theoretical background of the problem studied.

The structure of the work is following. Chapter II describes the timeline of the development of theory underlying monetary transmission mechanisms. In the third chapter, I show how investment behaves according to Tobin's *q* effect and balance-sheet channel of the monetary transmission mechanism with the particular emphasis on recent monetary developments as zero lower bound. Chapter IV presents common issues related to monetary policy transmission modeling and explains the model used for analysis followed by the description of the dataset used for its estimation. Following the modeling section, Chapter V provides the results of the empirical analysis. Finally, the Conclusions section reveals the overall results and offers policy recommendations.

II. Evolution of the Theoretical Background of Monetary Transmission Mechanisms

Comprehensive review on monetary transmission channels have been provided by Frederic Mishkin in 1996. Essentially, Mishkin is separating four channels that operate through interest rate, exchange rate, asset prices and credit supply. This chapter reviews the development of the theories underlying ways through which monetary policy can affect aggregate economic stance.

With the standing of the Keynesian IS-LM model, traditional channel of monetary policy transmission was considered to operate through interest rate. This theory suggests that during the expansionary phase of the monetary policy, fall in real interest rates leads to lower cost of capital and cause an increase in investment, which in turn positively affects aggregate demand and output. As Mishkin states, initially this type of transmission was mostly concentrating on business spending on investment, but later consumer expenditures on durable goods were also taken into account. However, the most important feature of this theory is that it focuses on real long-term interest rate, assuming sticky prices and rational expectations, thus making monetary policy functioning even when nominal rates are set to zero.

Empirical evidence on existence of interest rate channel was provided by Taylor (1995), but subsequently it was disputed by Bernanke and Gertler (1995), who did not identify significant effects of interest rate through the cost of capital. Empirical dissatisfaction served as a ground for development of theoretical grounding for other transmission mechanisms, particularly credit channel.

Exchange rate channel is suggested to work through net exports as a consequence of interest rate effect on attractiveness of deposits in domestic currency, thus leading to its

appreciation or depreciation, which in turn is affecting prices of domestic goods relatively to foreign.

Considering equity price channel, it is separated into Tobin's *q*, wealth, housing and land price effects. Tobin's q theory developed by Tobin (1963) proposes that monetary policy affects an economy through the valuation of equities. In this theory, key role is given to the so called indicator *q*, which is defined as relation of market value of the firm to the replacement cost of capital. In periods of high q, that is in period of monetary easing, when monetary base is expanding and public spending on stocks is rising, pushing the stock prices upwards, companies are expected to increase their investment spending as they can finance it by relatively smaller issues of equity.

Although wealth effect comes out of increasing consumption as a result of rising equity prices, it does not go beyond the individual's prosperity. It rather concentrates on Modigliani's life-cycle theory stating that consumption is determined by life-time resources. As value of the stocks is one of the main contributors to financial part of life-time resources, expansionary monetary policy and associated with it growing asset prices are resulting in increasing wealth and consumption expenditures of individuals.

Recently, there have been attempts taken in order to estimate quantitative relationship between monetary policy and asset prices. Chen and Wu (2013), using the threshold model, find that there is inverse U-shaped relationship between interest rates and stock indexes, which is contradictory to traditional wisdom.

Increases in house and land prices can be considered as a combination of Tobin's *q* and wealth effect. Firstly, higher ratio of house or land value to replacement cost is stimulating housing production. Secondly, higher values property in the form of house or land are directly contributing to the individuals' wealth thus leading to an increase in consumption.

It is worth mentioning that the development of the newer monetary transmission channels was mainly promoted dissatisfaction and oversimplification of theories lying behind the interest rates and expenditures relationship. These facts resulted in increasing attention to asymmetry of information in financial markets as an explanatory factor for existence of broad credit channel.

More specifically, credit channels are operating through banking lending and balance-sheet of the firms and households. As Mishkin (1996) emphasizes, bank lending channels is being provoked by low interest rate environment that is making it affordable for banks to accumulate higher volume of reserves and deposits, thus increasing the quantity of bank loans supplied. Nonetheless, is it not obvious how increasing deposit base can be consistent with previously aforecited theories of increasing consumption expenditures due to higher attractiveness of spending comparing to keeping available money resources on bank deposit account. Excessive lending should attract firms that otherwise would not be able to have an access to external funding sources, especially those characterized by smaller size and less reliable on internal sources of finance. Loans availability is supposed to result in higher investment and consumer spending contributing to general economy's higher output. In contrast to previously described monetary transmission mechanisms, bank lending channel is overexposed to regulatory restrictions, thus monetary policy effectiveness might be undermined in this case.

Numerous contradictions related to the bank lending channel theoretical grounding, as well its predisposition to macro-prudential regulations that is usually accompanying loose monetary policy, has led to switching attention to balance-sheet channel, that is also emphasizing problem of asymmetric information, which induces a premium in the cost of all forms of external finance over the cost of internal funds, as it is stated by Oliner and Rudebusch (1996). Nevertheless, recent studies still confirm the effectiveness of the bank lending channel in contrast to the interest-rate

channel in emerging markets, as Wulandari (2012) shows, and rejects its effectiveness in developing countries (Milcheva, 2013).

Development of the broad credit channel theory was forced by the existence of the gaps in the explanation of monetary effects caused by the insignificant cost-of-capital effects in spending equations found in the empirical studies devoted to find quantitative proof of importance of interest-rate related instruments in determining the trends of aggregate spending. However, this development was not aimed to mitigate the links of interest rate channel to economy's performance, but rather, following Bernanke and Gertler (1995), credit channel should be considered as "an enhancement mechanism, not a truly independent or a parallel channel", and in reality credit channel is representing "a set of factors that amplify and propagate conventional interest rate effects".

According to Oliver and Rudebusch (1996), broad credit channel is suggesting that a firm's investment spending is increasingly determined by internal financing sources during the tightening phase of a monetary policy. The link between use of internal funding and monetary contraction is reflecting higher premium for external funds in the higher interest rates environment. Otherwise, should broad credit channel be absent, the structure of funds used on capital expenditures would remain stable regardless the changes in interest rates. Broad credit channel includes also the balance-sheet channel hypothesis, the existence of which is due to the fact that credit markets are facing the situation when firms with lower net worth are objects to adverse selection and moral hazard.

Most of the studies related to broad credit channel are concentrating on banking sectors' lending, not paying specific attention to balance-sheet component of industrial firms and its importance for investment planning. Empirical evidence on functionality of the broad credit

channel in the U.S. was provided by Cicarelli et al. (2013): business and mortgage loans as a parts of broad credit channel could be the most significant transmissions for GDP growth, as a policy's effect on GDP and price would be lower by more than 50%. Jimenez et al. (2012) in their study using Spanish credit data reveal that higher short-term interest rates or lower GDP growth reduce the probability that a loan application is granted, especially for the banks with weaker characteristics of their balance-sheet. Hendricks and Kempa (2009) find that the credit channel is powerful, especially during periods of financial distress.

Regarding the post-crisis research on monetary transmission, it mostly pays attention to the role of a monetary policy to formation of financial instability coming out of excessive risk-tolerance. The relationship lying under the monetary policy actions and the perception and pricing of risk by economic agents was discovered to be a bank risk-taking channel.

It was suggested by Borio and Zhu (2008) that risk-taking channel may operate through three ways. The first way is enabled through the impact of interest rates on valuations, incomes and cash flows, while it is assumed that risk tolerance increases with wealth, which, in turn, is encouraging risk-taking. This set of effect might overlap with previously mentioned bank-lending channel. Secondly, excessive risk-taking might be a result of so-called "search for a yield" effect, which is led by an interaction of interest rates and "sticky" rate-of-return targets and is influencing risk-tolerance. Third effect, so called "insurance effect", is considered to be operative depending on the transparency of a central bank, that is assumed to compress the risk premia; however, due to perception of the effectiveness of a policy reaction function in cutting downside risks, and presence of asymmetric information, change in the policy, particularly decrease in rates, may result in more than expected risk-taking.

Recent empirical studies by Valencia (2014), Jimenez et al. (2014), Dell'Ariccia et al. (2013), Altunbas et al. (2010), have found statistically significant evidence on the causal relationship between monetary policy rates and different aspects of banks' loan-financing, as well as bank risk-taking in general.

In contrast to previously mentioned studies, this thesis aims to combine broad credit and asset prices channels effect from the point of view of company's investment. In particular, I try to find an evidence for interaction between balance-sheet and Tobin's *q* effects along the tightening and easing phases of monetary policy, similarly to Hu (1999). The next section is devoted to the detailed description of how investment decisions can be determined through the above mentioned interaction.

III. Monetary-policy based investment planning

3.1 Interest rates and Tobin's q effect

Traditional wisdom in regard of investment decisions would assume that during easing phases of monetary policy, a rational firm is increasing capital expenditures, as in this phase it is relatively cheaper, despite the credit quality of an entity or its size of operations, to finance its investments with external funds and not to rely on retained earnings. This oversimplified approach does have something common with a firm's reality, however it does not disclose anything about how exactly a firm can be motivated to adjust capital expenditures depending on the phase of the cycle of monetary policy.

There have been numerous attempts to theoretically line up corporates' investment decisions with the behavior of interest rate and money supply, most of which are concentrating on asset prices and broad credit channels of monetary transmission mechanisms. Thus, in their detailed study on the evolution of monetary transmission mechanisms, Boivin et al. (2010) are emphasizing that cost of capital has a particular importance for investment and is closely related to the Tobin's *q* channel.

Tobin's *q* theory developed in Tobin's work on a general equilibrium approach to monetary theory in 1969, is suggesting that a business investment is determined by an indicator *q*, which is a ratio of market value of firms divided by replacement cost of capital. The higher the *q*, the cheaper the capital, in practice meaning that a company has to issue less amount of stock to finance the same expenditures on facilities or equipment comparing to the period, when the *q* is low. As a result, investment should rise. Particularly, invest incentive is stronger, if the ratio is greater than 1, that is a firm's cost is undervalued in the open market.

As Tobin mentions, the principal way in which financial policies and events could affect aggregate demand is by changing the ratio described above, and the monetary policy can accomplish these changes, however, in Tobin's opinion, measuring this impact is complicated due to the influence of explicit variables, and it is highly presumably that using a single monetary shock as an explanatory variable is not helphul in capturing the impact.

The findings of the studies related to the Tobin's *q* ratio are contadictory. Recent research reveals an evidence of the Tobin's q responsiveness to monetary policy. Faria et al. (2012) claim that responses of *q* ratio have been varying before and after 1983 (so called pre- and –post Paul Volcker era). Earlier Faria and Mollick (2010) find that price movements have a long-run negative impact on the Tobin's *q*, while Bhattacharya et al. (2006) claim that the Tobin's effect is always operative. However, Gilchrist and Leavy (2002) state that Tobin's link between the asset prices and investment does not take into account investment adjustment costs and the marginal value of capital that is valuable for investment, causing the ratio to be hardly sufficient statistic, while cash flow or a lagged *q*-ratio is proved to be more useful. In addition, there were studies, including Blanchard (1993), Bond and Cummins (2000) show that the problem with *q* ratio is not lying in the ratio itself, but rather it is the deviation of stock prices from fundamentals that is causing managers to ignore signals coming out of the asset prices.

Special attention should be paid to the studies that are accessing association between inflation and the Tobin's *q*, as they incorporate intermediate output. Basu et al. (2012) provide evidence on negative correlation between the two indicators. The relationship works in the following way: higher money supply growth causes higher inflation, lower output growth, and a lower *q* in the long-run. Further, Gillman and Kejak (2011) show that inflation decreases the investment rate. It is worth mentioning, that the studies assessing inflation are often showing

contradictory results to the studies related to short-term interest rates, thus intriguing for a challenge to describe what is happening in the economy meanwhile short-term interest rates convert into observed inflation, however this study is not aimed to explain this puzzle and concentrates only on shocks in short-term interest rates with applying other possible controls on existing monetary indicators.

3.2 Firm balance-sheet and interest rates

Considering the behavior of balance-sheet indicators during different phases of monetary cycles, Mishkin (1996) is proposing that the balance-sheet can respond in several ways, all of which in the end are influencing adverse selection and moral hazard problems – the core reason for the existence of the broad credit channel.

Adverse selection is more likely to occur in times when lenders have lower discounted value of collateral for loans, thus facing risk to lose more. Rise in adverse selection, which is supposed to negatively affect lending, leads to lower possibilities for firms to finance their planned investments. The problem of moral hazard, according to Oliner and Rudebusch (1996) is due to the fact that a firm is exposed to default on its external debt obligations rather than on the implicit ones. The higher the debt, the more chances for a moral hazard issue to occur, and the higher risk-premium for external funds is required by lenders. The minimum threshold of premium, or cost for internal funds, is determined by risk-free rate that highly is dependent on interest rate set by a country's central bank. Summarizing the above, lender should expect the number of firms, who are less able to finance investment with internal funds, to be bigger in times when it is more affordable to cover premiums, that is in periods when the interest rates are low.

The first link, proposed by Mishkin, recalls of the Tobin's q effect in the way that the connection lies in asset prices. However, in contrast to Tobin's ratio of market value to assets'

replacement cost, higher net worth stimulates investment spending and aggregate demand as a result of lower adverse selection and moral hazard.

The second way of a firm's balance sheet being influenced by monetary policy is switching from a net worth to cash flow dynamics under the influence of monetary conditions: lower nominal interest rated cause higher cash flow, which result in lower chances for a presence of adverse selection and moral hazard problems. Here, the importance of the nominal interest rates should be highlighted, as this fact is differentiating the balance-sheet related effect from the direct interest-rate channel, centered at real rates. In addition, short-term rate should be considered as more valuable determinant of cash flows in comparison to long-term rate.

The third connection of a firm's net worth and monetary policy is concentrated on general price level, and is based on the mechanism explained by Fisher (1933) in his debt-deflation theory. According to this theory, exogenous shocks are being transmitted by debt in the following way: as unanticipated fall in the prices leads to a decline in borrower's net worth and, as a result, the real debt burden rises turning into less borrowing and investment. Inversely, when lower prices are pushing up the firm's net worth and decreasing debt burden, one has to expect lower chances to make adverse selection or face the moral hazard.

Significance of the balance-sheet channel has been tested on the various types of data with the application of different dynamic and static models, from which the most recent ones concentrate on factor-augmented vector auto-regression (FAVAR) models applied to banking sector. Thus, Boivin et al. (2010) note a reduction in the response of credit following an innovation in monetary policy, although in their work supply and demand sides of credit are not distinguished. Kabundi et al. (2013) conduct empirical study on a wider dataset, including balance-sheets of various economic agents, and find that balance sheets act as important links in the monetary

transmission mechanism; however, in case of financial intermediaries, except money market funds, balance sheets are shrinking in response to monetary tightening.

In this study, similarly to Hu (1999), I emphasize a change in the leverage as a driving force of balance-sheet channel of monetary policy and its impact on capital expenditures, using panel data on S&P500 firms, excluding financial sector. Hu (1999) applies Tobin's *q* model on the data of the U.S. manufacturing corporations, and finds an evidence for the existence of broad credit channel, operating through leverage. The author states that the main effect of adverse monetary shocks is embodied in the decrease of debt burden and increase of effective costs of investments. Similar study, using VAR approach was conducted by Zulkhibri (2013) on the sample of 900 listed firms in Malaysia aimed at examining the empirical evidence on the credit channel of the monetary transmission mechanism within the framework of corporate investment. Their results suggest that monetary policy significantly impacts firms' access to external finance during times of increasing interest rates, in particular, bank-dependent firms become the most vulnerable firms in this sense. González-Aguado and Suarez (2015) in their paper explore the effects of shifts in interest rates on corporate leverage and default in the context of a dynamic modelling. The results suggest that the firms' investment is pushing their leverage upward, and at some point it is supposed to reach the so-called state-contingent target, above which firms start to adjust the investment through retained earnings. Furthermore, the authors find firms' responses to be both asymmetric and heterogeneously distributed.

An impact of interest rate shifts on leverage was also studied by Cooley and Quadrini (2006) with emphasis on the differences in firms' size. The authors find that the responses of small and large firms to monetary shocks differ substantially: small firms are found to be more responsive.

Fu and Liu (2015) examine monetary and credit channels on the Chinese firms' dataset. They show that the monetary policy has a significant effect on the corporate investment adjustment speed, through money supply and credit supply, and the effects are significantly greater during tightening than expansionary periods. The authors are also emphasizing a significant asymmetry, accompanying the money supply channel. In addition, the results suggest that the leverage moderates the relationship between monetary policy and investment adjustment, with a greater effect in expansionary periods.

3.3 Assets prices and monetary policy

From the previous sub-chapters, we can conclude that the majority of the problems related to efficiency of Tobin's q are related to the link between assets prices and monetary policy. Not by chance, research attempts to clear out the relationship between them have a long story, emphasized by difficulties on providing a theoretical grounding for monetary policy to take into account asset prices.

Asset prices are considered to be an economic category, which is, according to Gilchrist and Leahy (2012), "aggregate information from diverse sources in a timely matter and are obvious candidates to be proxies of the underlying state of the economy effects". In the same time, Bernanke and Gertler (2000) claim that "there are periods when asset values seem all but disconnected from the current state of the economy".

Due to the variety of links to economy's performance coming out of monetary policy from one side, and economic information-richness of asset prices from another side, it is difficult to judge about endogeneity of assets price in relation to interest rates behavior. Despite this fact, results of the study by Rigobon and Sack (2004) using an estimator that is based on the heteroskedasticity that exists in high-frequency data, indicate that stock prices (including Dow

Jones Industrial Average, the S&P 500, the Nasdaq, and the Wilshire 5000) decline in response to an increase in short-term interest rate. This study, however, concentrates only on short-term effects, using daily data, and results might not be correctly extrapolated to a longer time period.

In contrast to high-frequency analysis, which allows to account for a highly volatile nature of asset prices, analysis of long-term relationship with monetary policy is limited largely due to the reasons mentioned above: in the long-run asset prices incorporate enormous amount of information about the economy's condition, and sometimes these prices are accompanied by non-economy driven behavioral trends, as it usually happens during periods of financial booms.

Nevertheless, Bordo and Landon-Lane (2013) using the panel data on 18 OECD countries show that 'loose' monetary policy, identified by interest rate level below the target rate (or a money supply growth rate above the target rate), has positive effect on asset prices. Their results are especially important, since their robustness is proved across multiple asset prices and different specifications, while controlling for a low inflation or 'easy' credit as other alternative explanations of assets prices.

Despite the partially proven responsiveness of asset prices to changes in interest rates, asset prices are found as a poor determinant of inflation, thus assets prices fail to be included into the policy rule equations within the inflation targeting framework. Stock and Watson (1999) show that there is little evidence that stock prices explain consumer price index trends, and claim that the measures of real economic activity perform the prediction task in a better way. Gilchrist and Leahy (2012) conclude that asset prices do not contain information valuable for forecasting inflation, with emphasizing that the reason for this lies in the fact the assets prices do not contribute much in addition to lagged output and consumption, despite that the asset prices, output and consumption are correlated. Similarly, Bernanke et al. (1999) in stochastic general equilibrium framework find

there is no grounding to account for asset prices into a policy rule, as the rule includes output and expected inflation that already capture most of the gains from including stock prices, while non-fundamental information contained by asset prices and not represented by output and expected inflation can distort the rule by increasing potential for financial panics to arise.

3.4 Zero lower bound and unconventional monetary policy transmission mechanisms

Previously described mechanisms of monetary transmission are concentrating on the change in interest rate triggering reactions of economic agents in order to adjust to shifts in credit supply, asset prices, exchange rate and other intermediary elements. Despite the presence of empirical confirmation of importance and relevance of a specific link in monetary transition, these mechanisms are largely reflecting the pre-crisis approach to monetary policy, not paying any attention to unconventional measures that have been recently considered as panacea of economic renovation in conditions of interest rates close to zero, or zero lower bound situation.

Noteworthy, zero lower bound framework is questioning the whole theory underlying the monetary transmission, as a monetary authority lacks freedom to operate through its fundamental tool, - interest rate. However, unconventional measures, particularly purchase of wide spectrum of financial assets, is still valuable instrument for expansion of the credit, with the only difference, according to Gertler and Karadi (2010), in that a central bank plays the role of financial intermediation instead of a private sector, with benefiting from advantages of the absence of a balance-sheet constraint and ability to obtain the funds elastically. Thus, instead of a traditional effect of open market operations, influencing balance-sheets of private financial intermediaries, which in turn are determining the overall flow of credit, a monetary authority acts as a direct creditor.

If the biggest divergence between the transmission of traditional monetary policy and unconventional is touching the question who plays the role of financial intermediary, then the core issue in terms of the current paper is whether the unconstrained balance-sheet and almost boundless ability to generate the funds (in regard that supply of some of financial assets, particularly government bond, is limited) can act differently through already mentioned channels of loan supply, asset prices (including wealth and Tobin's q effect), exchange rate and long-term rate, or even involve some other mechanisms that are not reactive to conventional monetary measures.

According to Gertler and Karadi (2010), there is a consensus on the influence on unconventional monetary tools, that is, it puts downward pressure on yields and long-term interest rates that turn into positive economic effect in general. Results of the paper show that indeed unconventional measures resulted in lower than expected contraction of the output and smaller decrease in inflation rate. However, this does not clear out the channel through which it works. Nevertheless, Joyce et al. (2012) in their study show that the impact on price level is weaker and less persistent than of the conventional measures, and they still emphasize the existing uncertainly over the magnitude and continuation of the effect of unconventional measures, and highlight the fact that there is no precise channel through which they work.

Relative scarcity of historical examples on the usage of unconventional monetary measures makes it difficult to estimate specific channels of its influence, and often results in contradictory results. Hence, Wright (2012) provides evidence that overestimation of the influence of quantitative easing on private yields has led to overstated response of an aggregate demand in previous studies. Furthermore, the author highlights that the effects from policy shocks vanish faster than it was assumed by Chung et al. (2011).

Apart of that, effects of zero lower bound policy, which serves as a ground for introduction of unconventional measures and open market operations, is found to be highly dependent on the specification of the Taylor rule, as it shown by Reifschneider et al (2000). McCallum (2010) discovers that inflexible short nominal interest rate still leaves room for effectiveness of monetary policy via foreign exchange market.

From the perspective of firms' investment reactions, it is important to have a proper substitute for a short-interest rate, that would reflect monetary stance in times then there is no much variation in the conventional instrument. Important findings were made by Wu and Xia (2014), who construct a measure to study unconventional monetary policy that can be used instead of widely used effective funds rate (more detailed description of the measure is provided in Monetary indicators section of the Chapter IV). Analysis of the constructed shadow rate confirms the effectiveness of unconventional measures in reducing unemployment, and the measures were found to provide more stimulus than a historical version of the Taylor rule.

The novelty of the current thesis is that I account for the appropriateness of monetary indicators to estimate the effectiveness of monetary transmission: the model using proposed by Wu and Xia shadow rate in the time period when the Federal Reserve bank switched to unconventional monetary policy and the interest rates do not show a significant variation.

IV. Model and Data

4.1. Model description

4.1.1. Micro-level investment model

In this work I replicate the modeling approach by Hu (1999) that is aimed to estimate the effect of monetary policy on firms' investment through leverage in Tobin's q-investment model. The model assumes perfect competition, constant returns, and capital as the only quasi-factor, the marginal q of a firm to be a sufficient statistic of the firm's investment opportunities approximated by its average. Reduced equation for investment is following:

$$\frac{I_{it}}{K_{it}} = \alpha_i + \beta Q_{it} + \sigma_t + u_{it}\,, \qquad (1)$$

where I_{it} is capital expenditure, K_{it} is the capital stock, Q_{it} is average q defined as the ratio of the market value of capital to replacement cost, or its book value; α_i reflects firm-specific effects, which are assumed to be constant over time, σ_t accounts for cyclical factors that have common effects on all firms, and u_{it} is stochastic disturbance term.

Use of micro-level data is aimed to account for the heterogeneous reactions across the firms and makes it possible to compare firms representing different sizes and industries. Oliner and Rudebusch (1996) find that the connection of internal funds and business investment is closely correlated for small firms during periods of monetary tightenings. Heterogeneity in the transmission mechanism of monetary policy was also studied by Ciccarelli et al. (2013), Bluedorn and Bowdler (2013), with the particular importance found in banks' and firms' sizes. Nonetheless, use of the micro-level data has its disadvantages as well. Some studies are pointing out that the

micro identification cannot analyze total effects of a monetary policy shock on real activity, but only difference-in-difference effect, according Kashyap and Stein (2000).

Based on the above mentioned advantages and disadvantages of using macro or micro level data, I decide to perform micro-level panel data analysis to reflect differences in firms' reactions, taking into account their size and industry.

Another dimension of the model's performance is opened with the accounting for dynamic in firm's investment. Thus, equation (1) is going to be expanded to equation (2) with lagged control variables (lag structure is identified based on autocorrelation), sales to capital stock (S/K), market leverage (D/V), interaction term between market leverage and dummy on monetary tightness (IND), industry dummies (ID) and seasonal quarterly dummies (SD). Weighting firms' operative performance indicators with their capital stock allows to take into account size differentiation within the panel.

$$\frac{\boldsymbol{I_{it}}}{\boldsymbol{K_{it}}} = \boldsymbol{\beta_1}\frac{\boldsymbol{I_{it(-1/-4)}}}{\boldsymbol{K_{it(-1/-4)}}} + \boldsymbol{\beta_2 q_{it}} + \boldsymbol{\beta_3}(\boldsymbol{S/K})_{\boldsymbol{it}} + \boldsymbol{\beta_4}(\boldsymbol{D/V})_{\boldsymbol{it}} + \boldsymbol{\beta_5 IND_{it}} + \boldsymbol{ID_i} + \boldsymbol{IS} \qquad \textbf{(2)}$$

The empirical estimation of the model is concentrating on the coefficients on interaction term of monetary policy regime dummy variable and a firm's leverage ratio. I explore the hypothesis that the investment's association with the leverage is negative during tigthening periods, as a firm prefers to not to issue a debt due to higher financing cost and lower net worth of the firms, that makes it more less probable to get an external financing, as a creditor faces higher adverse selection and moral hazard.

4.1.2. Monetary indicators

The next step in the development of the model is to distinguish between easing and tightening periods of the U.S. Federal Reserve monetary policy. For identification of monetary phase, I use Effective Federal Funds Rate. This indicator was suggested by Laurent (1988) and Goodfriend (1991) as a good approximation for a stage of monetary policy and was used in empirical research by Hu (1999), Oliner and Rudebusch (1996). Monetary tightenings are considered to be those quarterly periods characterized by increases of at least 25 basis points, similarly to Hu (1999) and Cicarelli (2012).

Considering the time frame analyzed in this thesis, in approximately half of the time series, including post-crisis period (from the end of 2008), interest rates do not show much of variation (Graph 2), which could distort the analysis.

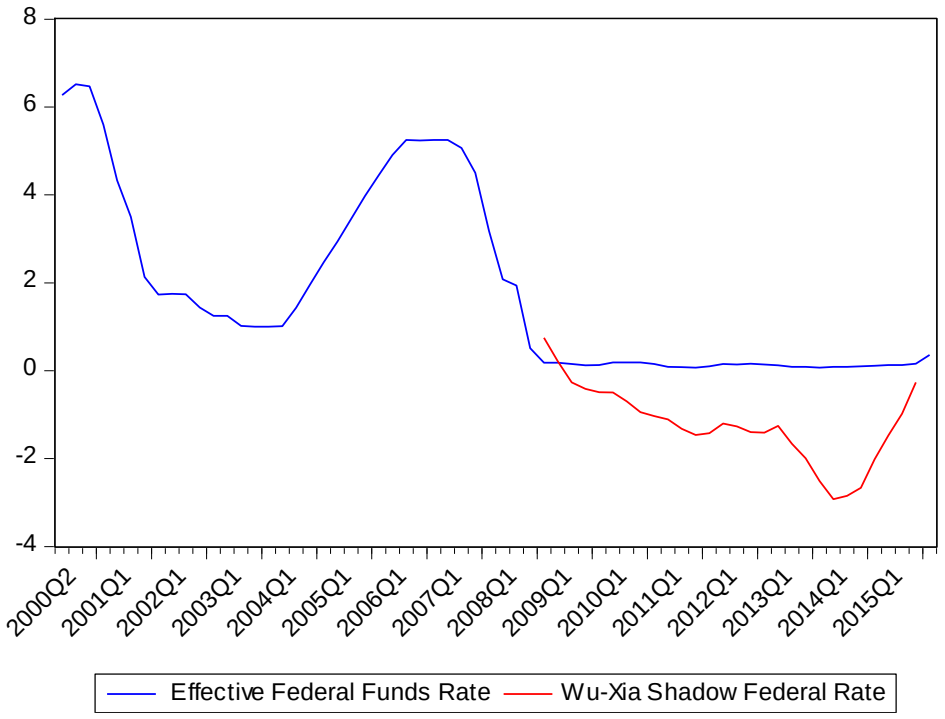

Figure 1 Effective federal funds rate and Wu-Xia shadow rate[2]

[2] Based on the data provided by Federal Reserve Bank of St. Louis and Atlanta. Available online at: https://research.stlouisfed.org/fred2/series/EFFR

As it was mentioned in the Chapter III, this phenomenon, is the consequence of Federal Reserve zero lower bound framework and accompanying concentration on unconventional mechanisms. To account for this, in the second modification of the main equation I use shadow federal funds rate[3] constructed by Wu and Xia (2015), dynamics of which is represented on the Graph 1 above. According to the authors, in times when the lower bound is binding, the shadow rate contains more information about the current state of the economy than does the short-term interest rate; in addition, their result show that shadow rate could be used to update the existing research based on the effective federal funds rate. Significance of a shadow rate as a measure of monetary policy stance was also confirmed by Kim and Singleton (2012), Bayer and Rudenbusch (2013), Bullard (2012) and Krippner (2013).

The Wu-Xia shadow rate is estimated by the shadow rate term structure model (SRTSM) discussed in Wu and Xia (2014), and defined as the maximum of the shadow federal funds rate and a lower bound calibrated to be 25 basis points (thus since the beginning of 2009 short-term rate is equal to shadow rate). As the inputs in SRTSM, the authors use 7 forward rates of different maturities up to 10 years, constructed with the Nelson-Siegel-Svensson yield curve, based on the dataset provided by Gurkaynak et al. (2006).

The Wu-Xia shadow federal funds rate is implemented in first specification the interaction term with leverage, similarly to interaction term with effective federal funds rate (comparison of results with different interaction terms are presented in Chapter 5); second specification includes first difference of the shadow rate as a control variable. Price changes driven by industry-specific

[3] Statistics and description of the Wu-Xia shadow federal interest rate are available at: https://www.frbatlanta.org/cqer/research/shadow_rate.aspx?panel=1 . The rate is updated on a monthly basis.

features and development are assumed to be controlled with the help of inclusion of industry variables.

4.1.3. Financial frictions and adjustment costs

Post-crises research has been increasingly concentrating on the implications of the costs that firms are facing from the financial transactions occurring due to imperfection in financial markets. Kolasa and Lombardo (2011) claim that, in overall, financial frictions have been considered as sufficient reason for central banks to switch their targets from reaching price stability to adequately responding productivity shocks, following shifts in investment adjustment costs, including depreciation and new investment.

Relevance of financial frictions for firms' investment decisions was studied by Gilchrist et al. (2014), who investigate the macroeconomic implications of uncertainty and financial shocks, and come to the conclusion that both types of shocks affect investment and result in countercyclical credit spreads and procyclical leverage in a significant way. These results, however, contradict to earlier studies, for example, Cooper and Ejarque (2002), who find that market power indeed induces the principal link between investment and internal funds, but in the same time there is no evidence in support of the fact that capital market imperfections influence the connection between investment and profitability.

To account for a possibility of financial frictions influencing investment decisions, I follow the methodology proposed by Claessens et al. (2010), and I add to equation (2) instrumental variables for lagged the leverage ratio: adjustment costs in the form a squared change of ratio of capital expenditures to capital and financial transaction costs in the form of squared change of the ratio of a firm's debt to its capital.

4.1.4 Endogeneity of monetary policy

With the development of the monetary transmission mechanisms theory, researchers have been facing problem with specification of the models used for an empirical analysis. In one of the first studies devoted to broad credit channel, conducted by Bernanke and Gertler (1996), it was claimed that the credit aggregates are not valid tests for this theory. Later, in 2010, Boivin et al. still emphasize that one of reasons for less interest to non-neoclassical, or credit-type channels, is the remaining difficulty to empirically assess credit mechanisms with macroeconomic data and models. In this section I try to acknowledge difficulties related to monetary transmission modeling and I show how this study adjusts for the issues revealed in the recent studies.

Most issues pertinent to modeling of monetary policy are often concentrated on the question if changes in the policy are exogenous. According to Davig and Leeper (2008), exogeneity assumption is largely coming out of the Taylor rule framework, core line of which is that "monetary policy behavior is purposeful and reacts systematically to changes in the macroeconomic environment". Beside the Taylor rule, Carpenter and Demiralp (2010) argue that most models in the current macroeconomic policy analysis are excluding the possibility of modeling money or money demand as entirely endogenous. In order to distinguish exogenous and endogenous shocks, vector auto regression (VAR) approach has been used, though it was shown by Rudebusch (1998) to provide unstable coefficient estimates, while lately Bernanke et al. (2004) claim that VAR do not reflect some information of central banks and the private sector, and as a result, measurement of policy innovations is likely to be contaminated. In addition, VAR with many control variables included into equation is making the analysis boundless, and impulse responses can be observed only for the included variables.

Previously mentioned issues are largely faced in the research focusing on aggregated and macro level data. In this analysis I assume that endogeneity of a monetary policy is solved with the help of micro-level data, as a policy regime is not likely to respond to changes in the indicators of a particular firms or an industry. However, I do not exclude the possibility that endogeneity caused by inertia in monetary policy is solved by micro-level data.

4.2 Data

For this analysis I use quarterly data on firms included into S&P 1500 Composite Index as for 2016 year, which includes S&P 500, S&P 400 Mid Cap Index and S&P 600 Small Cap Index. The data is downloaded from Thomson Reuters, and financial firms are excluded from the sample. Details on the variable's included into analysis are presented in the table below.

Table 1 Dependent and control variables

Variable	Meaning and Calculation	Frequency of components and source of the data
I/K	Investment to Capital. Calculated as capital expenditures over the total capital	Quarterly, Thomson Reuters
q	Tobin's q ratio. Calculated as the ratio of average of the market capitalization of a firm to its total assets	Quarterly, Thomson Reuters. Market capitalization daily data is averaged over the corresponding quarter
S/K	Sales to capital. Calculated as the ratio of a firm's total revenue to its total capital	Quarterly, Thomson Reuters
D/V	Leverage. Calculated as the ratio of a firm's total debt to the average of its market capitalization over the period	Quarterly, Thomson Reuters. Market capitalization daily data is averaged over the corresponding quarter.
IND (IND2)	Interaction term. Calculated as a multiply of a firm's leverage (D/V) and dummy variable on monetary tightening based on the effective federal funds rate before 2009 and Wu-Xia shadow rate after 2009. IND2 takes into account only effective federal funds rate for the period 2000Q2-2016Q1.	Quarterly, Thomson Reuters and Federal Reserve Banks of St. Louis and Atlanta. Monthly data on effective federal funds rate is averaged over the corresponding quarter.
Ad_costs	Adjustment cost. Calculated as a squared change of capital expenditures over capital.	Quarterly, Thomson Reuters
Financ_friction	Financial frictions costs. Calculated as a squared change of debt over capital.	Quarterly, Thomson Reuters
Q1-Q4	Seasonal dummy variable for quarters	-
Sector1-Sector 9	Firm' s Industry dummy variable	Thomson Reuters

After initial processing of the data, number of firms included is 870, over the 64 quarters covering the time period from 2000 Q2 to 2016 Q1 with 53,388 observations in unbalanced panel. Descriptive statistics of the dependent variable, capital investment and other firms' characteristics as *q* ratio, leverage and market value, are presented in the table below.

Table 2 Main Characteristics of the Firms

Statistic	Capital expenditures	Leverage	EBITDA	Market value	Tobin's *q*
Mean	317.6799	0.530531	360.348	11209.23	2.411385
Median	40.3775	0.179694	69.1535	2143.634	1.088786
Maximum	37985	2414.306	293700	1135412	5061.391
Minimum	0	0	0	0.127518	0.000154
Std. Dev.	1186.456	12.5855	1672.303	34309.77	57.48469
Skewness	11.83653	153.6817	103.5473	9.10659	68.47173
Kurtosis	211.9322	27198.4	17763.7	141.4747	4906.035
Observations	53004	53324	53356	53388	53340

From the Table 2 above we can observe that firms included into sample are characterized by significant deviation from the mean for all the statistics displayed. This fact serves as an evidence for high potential heterogeneity of reactions, being one of the consequences of the significant variability of firms' sizes, playing important role in the aims of this analysis.

I construct industry dummy variable based on the sectoral breakdown according Standard & Poor's Methodology for indexes. The 870 companies in the sample are representing 10 sectors. Table 3 below contains description of sectoral breakdown of the data. The sample includes only non-financial firms, in addition some sectors are underrepresented due to their specialization, while industrial, non-cyclical consumer, information technology and healthcare firms account for approximately 70% of the sample.

Table 3 Sectoral Breakdown

Sector	Number of Observations	Percent
Basic materials	3,830	7.2
Consumer cyclicals	4,345	8.1
Consumer non-cyclicals	10,192	19.1
Energy	4,057	7.6
Healthcare	6,105	11.4
Industrials	11,853	22.2
Information technology	8,679	16.3
Telecommunications services	825	1.6
Utilities	3,502	6.6
Total	53,388	100.0

Particular interest of the analysis is to estimate the effects of monetary policy through Tobin's q and balance-sheet channels. Table 4 shows that energy sector is characterized by the largest investment projects (in relation to its total capital) – approximately triple as big as the total sample mean's level. Considering leverage ratio, the most indebted firms during 2000-2016 were mainly representing utility, telecommunication services, materials and industrial production sectors.

Table 4 Firms' Main Characteristics by Sector

Sector	Capital expenditures/ Total capital	Leverage	Tobin's *q*
Basic materials	0.041	0.48	0.93
Consumer cyclicals	0.0403	0.33	1.7
Consumer non-cyclicals	0.0474	0.44	1.41
Energy	0.1131	0.36	1.09
Healthcare	0.0318	0.2	2.25
Industrials	0.0426	0.67	5.45
Information technology	0.0372	0.14	2.07
Telecommunications services	0.0541	0.84	1.07
Utilities	0.0645	2.29	0.47
Sample mean	0.0481	0.53	2.411

According to Tobin's *q* theory, we should expect that overvalued firms (those with the Tobin's *q* ratio above 1) are prone to have higher capital expenditures due to relative costless of the capital, financed by share issuances. For example, utilities with the average Tobin's *q* of 0.47 have capital expenditures relative to capital higher than the mean, while in the same time are characterized by the highest leverage ratio, meaning that these companies are most dependent on the external finance, thus their expenditures on investment should be the most vulnerable to credit conditions and interest rates. In case of industrial firms, this relationship if somewhat doubtful: the highest q ratio does not lead the sector's investment far from the mean.

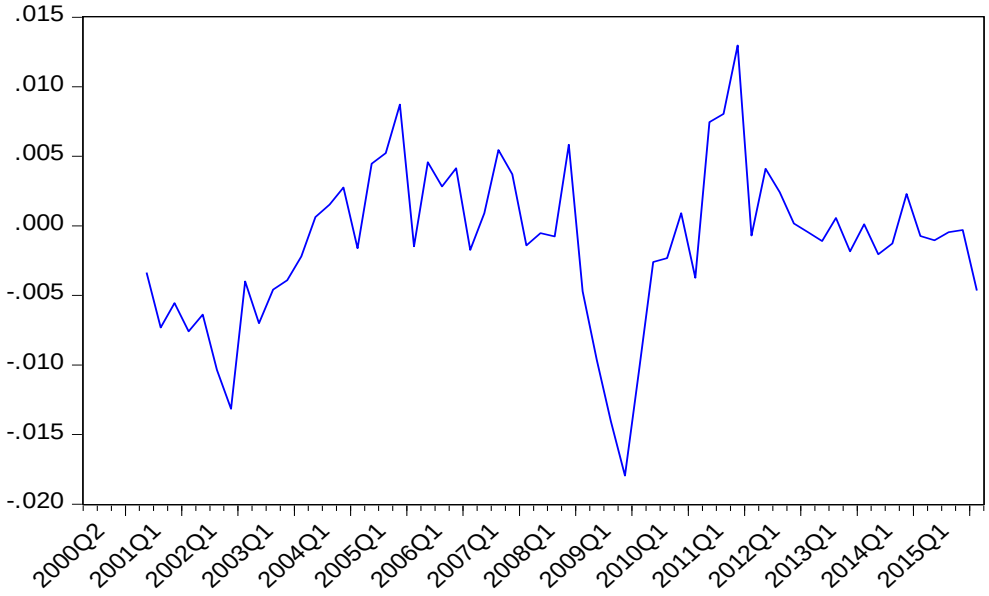

Figure 2 Mean of the Investment/Capital (Seasonal Difference of Logarithm transformation)

Thomson Reuters data for all the firm-level variables is not seasonally adjusted, thus I decide to use seasonal differences of logarithm modifications of the variables, depending on their seasonal pattern. On the graph above, sample mean for the dependent variable over the period from 2000Q2 to 2016Q1 is shown. We can observe that seasonal differenced modification is not solving the high seasonality pattern in the data. To account for seasonality and trends I additionally use

seasonal dummy variables. All the variables included into the model equation are additionally checked for non-stationarity (results of the test are disclosed in Tables A2-A5 of the Appendix).

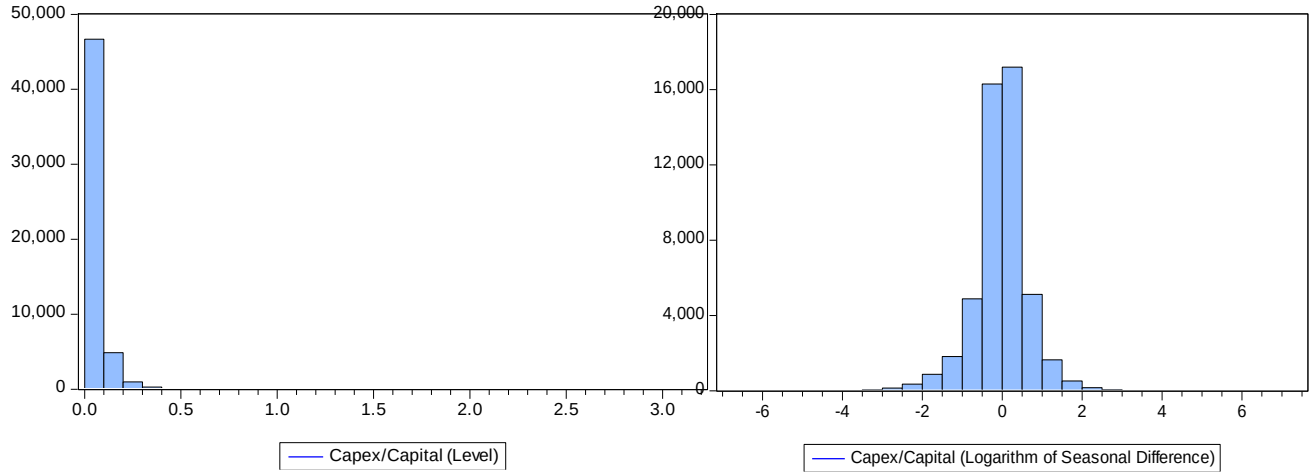

Figure 3 Distribution of Capex/Capital

On the graph above, histograms for capital expenditures to total capital (seasonal difference) and its logarithmic modification are presented. As it can be observed, capital expenditures weighted by the firms' capital are not normally distributed, and the relatively costly investments are not frequent events. Logarithm of the variable is slightly negatively skewed, meaning that average relative changes in firms' investment are smaller than of the median firm, and excess kurtosis supposes lesser probabilities of extreme volumes of investments.

One of the most important features of the dynamic analysis is identify autocorrelations, particularly for a dependent variable. Based on the correlogram for seasonal difference of the logarithm of capital expenditures to capital (Table A1 of the Appendix), I include 4 lags of the dependent variable into the dynamic model.

V. Empirical Results

I start the analysis with applying ordinary least squares (OLS) estimator to the model with transformed variables (seasonal differences) and checking for heterogeneity. Secondly, I estimate the model with clustered standard errors. After running the first and the second estimations, I apply the White test and the Breusch–Pagan test for conditional heteroscedasticity. Based on both Cameron & Trivedi's decomposition of information matrix (IM) test and Breush-Pagan Lagrange multiplier test, I reject homoscedasticity (results of the tests are presented in Table A6-A7 of the Appendix). These results imply necessity of the correction using White's heteroskedasticity-consistent standard errors in the dynamic model.

I introduce control for financial frictions and adjustment as instruments for lagged leverage ratio. In this exercise I test whether lagged leverage is playing role of a financial constrain for an upcoming investment. Results of the instrumental variable panel regression are presented in the Table A8 of Appendix. Both types of costs are found to be valid determinants for the leverage. Introducing these instruments, lagged leverage remains significant determinant for the investment in subsequent 4 quarters. I observe no significant reaction of the monetary indicator and sales weighed by capital, however Tobin q ratio gains importance in determining current changes in firms' investment. I note that the limitation of instrumental variables regression is that standard errors cannot be corrected for the heteroscedasticity revealed by the IM White's test.

To account for dynamics in the corporate investment, I apply Arellano-Bond estimators, with the instrumental variables of 4–steps lagged dependent variable, and financial frictions, adjustment costs, quarterly and industry dummies. Noteworthy, significant difference from the model estimated in Hu (1999) with the help of fixed effects is caused by specific features of Arellano-Bond dynamic panel estimator, substituting fixed firms' effects with the first differences,

thus initial inputs of dependent and exogenous variables are logarithmic transformations. Furthermore, comparing to Hu (1999), to avoid multicollinearity I exclude highly correlated controls of firms' operative performance.

I check two specifications of the interaction terms of monetary regime. The first includes combination of the change in the effective federal funds rate before the lower zero bound, or 2009, since when shadow rate is used for a definition of tightness. I check whether in the periods of tightness of a monetary regime, change in firm's leverage occurs to be a driving force of changes in firm investment. The second specification includes the interaction term based completely on effective federal funds rate, while controlling for Wu-Xia shadow rate is an input into the model equation and its first difference is used as an instrumental variable.

The results of different specifications based on the definition of the interaction term provide the evidence on the effectiveness of a monetary policy for stimulating the investment through leverage. Tightening of monetary conditions of the first specification appears to be significant at 90% confidence level: 10% change in leverage driven by 25 basis point increase in interest rate is associated with 0.002% decrease in investment. In addition, a change in leverage does play the role of a determinant of firms' investment: 10% increase in leverage is shown to be associated with 0.5% decrease in investment (Table A10 of the Appendix).

Second specification, based on the inclusion of the shadow rate, suggests the post-2009 monetary policy regime reflected in the forward rates and yield curves, is helpful in explaining firms' investment: with 1% decrease in the rate, a firm is expected to increase investments by 0.05.

I conclude that it is revenue relative to capital stock and firm market value relative to asset replacement costs are the most important firms' characteristics, defining levels of firms' investment, despite the monetary policy regime. Thus, the results suggest that Tobin's *q* channel

is operative, while the lagged values of the investment (4 quarters) are also significant determinants of the current level of the investment to capital ratio (detailed estimation output is presented in the Table A10 of the Appendix). Quantitatively, once the market value to asset book value ratio of a firm increases by 10%, a firms is expected to decrease its investment by approximately 0.6%; furthermore, reactions of Tobin's Q on average appear to be stronger in last 15 years than during the quantitative easing period as a result of higher responsiveness of investment to company's valuation in the pre-crisis period.

Considering firms' operating performance, change in the ratio of revenue to its capital by 10% during 1-year period is associated with approximately 4% increase in capital expenditures in the same financial year. Similar to Tobin's *q*, reactions in post-crisis period are weaker comparing to pre-crisis level.

Results of the Arellano-Bond test for autocorrelation in first-differenced errors show that the model is not completely able to solve autocorrelation of the second order (Table A11 of the Appendix). The Sargan's test for over identifying restrictions in the dynamic panel data model is not used, as the model is estimated with clustered standard errors.

VI. Conclusions and Policy Recommendations

The purpose of this thesis was to provide empirical evidence on the effectiveness of the U.S. monetary policy in stimulating corporate investment over the period 2000-2015. I assessed the effectiveness through the combination of Tobin's *q* effect and the balance-sheet channel of monetary policy transmission mechanism, operating through leverage. I considered a sample of U.S. non-financial companies included in S&P 1500 Composite Index, totaling in 870 firms representing 10 sectors.

I checked two specifications of the interaction terms of leverage and indicator of a monetary regime. The first includes combination of the change in the effective federal funds rate before the lower zero bound, or 2009, when shadow rate is used for a definition of monetary tightening. I checked if the 25 basis points increase in interest rate accompanied by a change in firm's leverage occurs to be a driving force of a firm investment. The second specification, used only for the period of zero lower bound includes the interaction term based completely on effective federal funds rate, while control for the Wu-Xia shadow federal rate is an input into the model equation.

Applying Arellano-Bond estimator in dynamic panel model I show that the change in the leverage driven by the shift in monetary policy regime is a significant determinant of a firms' investment. Investment also positively reacts to changes in ratios of sales to capital, and adversely - to market value to replacement cost (Tobin's *q*).

More specifically, tightening of monetary conditions of the first specification appears to be significant at 90% confidence level: 10% change in leverage driven by 25 basis point increase in interest rate is associated with 0.002% decrease in investment. In addition, a change in leverage

does play the role of a determinant of firms' investment: 10% increase in leverage is shown to be associated with 0.5% decrease in investment. In addition, post-2009 monetary policy regime reflected in the forward rates and yield curves, is helpful in explaining firms' investment: with 1% decrease in the rate, a firm is expected to increase investments by 0.05.

The results suggest that Tobin's *q* channel is operative, however in the contradictory way. Quantitatively, once the market value to asset book value ratio of a firm increases by 10%, a firms is expected to decrease its investment by approximately 0.6%; furthermore, reactions of Tobin's *q* on average appear to be stronger in last 15 years than during the quantitative easing period as a result of higher responsiveness of investment to company's valuation in the pre-crisis period. Considering firms' operating performance, change in the ratio of revenue to its capital by 10% during 1-year period is associated with approximately 4% increase in capital expenditures in the same financial year. Similar to Tobin's *q,* reactions in post-crisis period are weaker comparing to pre-crisis level.

The results disclosed above suggest that if a firm's leverage reacts to shifts in regimes of a monetary policy, increase in external borrowing might be in use for capital investments. This fact constitutes important conclusions for a monetary policy-based stimulation of an economic growth: higher cost of external finance might imply lower capital investment, serving as an evidence that the balance-sheet channel of a monetary policy transmission mechanism is operative for non-financial firms, similar as shown by Hu (1999). However, these conclusions should be considered carefully since the presence or absence of statistically significant reactions might be sensitive to the definition of monetary tightening. Reconsideration of the definition of monetary tightening applied in recent studies, including Cicarelli (2013), formulates a potential scope of further developments in the methods used to assess monetary policy effectiveness.

As an increase in market value of a firm relative to its replacement cost, or asset value, is shown to be significant determinant of a decrease in capital expenditure, tightening of monetary conditions in general might act negatively through the asset prices. Financial frictions and adjustment costs occurring as the consequence of market imperfections do not interrupt the former link.

Noteworthy, attempts to use unconventional monetary tools, as quantitative easing, while maintaining zero lower bound, might result in positive reactions of corporate investment. This influence remains sensitive to the effects of unconventional policies on forward rates and yield curves, determining shadow federal interest rate developed by Wu-Xia (2015). Nevertheless, the extent to which a central monetary authority can act as a direct creditor still should be determined with a high precision to avoid adverse reactions of economic agents.

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Appendix

Table A1. Correlogram for Investment/Capital (Seasonally Differenced Logarithmic Transformation)

	AC	PAC	Q-Stat	Prob
1	0.358	0.358	6327.8	0.000
2	0.153	0.029	7486.9	0.000
3	0.144	0.092	8508.1	0.000
4	-0.288	-0.429	12587.	0.000
5	-0.175	0.076	14091.	0.000
6	-0.009	0.093	14095.	0.000
7	-0.120	-0.034	14806.	0.000
8	-0.089	-0.206	15198.	0.000
9	0.024	0.069	15227.	0.000
10	-0.069	-0.006	15459.	0.000

Table A2. Unit Root Tests Summary for Seasonally Differenced Logarithm of Investment to Capital

Panel unit root test: Summary
Series: Investment/Capital
Sample: 2000Q2 2016Q1
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 10
Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-2.15197	0.0157	870	45525
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-82.8075	0.0000	870	45525
ADF - Fisher Chi-square	10868.8	0.0000	870	45525
PP - Fisher Chi-square	14048.4	0.0000	870	47883

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Table A3. Unit Root Tests Summary for First Difference of Logarithm of Leverage

Panel unit root test: Summary
Series: Leverage
Sample: 2000Q2 2016Q1
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 9
Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-189.892	0.0000	847	43983
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-184.589	0.0000	845	43977
ADF - Fisher Chi-square	27288.0	0.0000	847	43983
PP - Fisher Chi-square	29265.8	0.0000	847	44325

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Table A4. Unit Root Tests Summary for First Difference of Logarithm of Tobin's Q

Panel unit root test: Summary
Series: Q
Sample: 2000Q2 2016Q1
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 10
Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-10.1895	0.0000	870	46978
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-67.1345	0.0000	870	46978
ADF - Fisher Chi-square	8378.96	0.0000	870	46978
PP - Fisher Chi-square	8313.72	0.0000	870	48918

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Table A5. Unit Root Tests Summary for Seasonally Differenced Logarithm of Sales to Capital

Panel unit root test: Summary
Series: Sales/Capital
Sample: 2000Q2 2016Q1
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 9
Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-18.3838	0.0000	870	46925
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-79.5446	0.0000	870	46925
ADF - Fisher Chi-square	10555.7	0.0000	870	46925
PP - Fisher Chi-square	12214.3	0.0000	870	48739

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Table A6. IM White Test and Cameron & Trivedi's Decomposition of IM-test

White's test for Ho: homoskedasticity

against Ha: unrestricted heteroskedasticity

chi2(209) = 15658.41

Prob > chi2 = 0.0000

Cameron & Trivedi's Decomposition of IM-test

Source	Chi2	df	p
Heteroskedasticity	15658.41	209	0.0000
Skewness	1834.65	21	0.0000
Kurtosis	19.89	1	0.0000
Total	17512.94	231	0.0000

Table A7. Breusch and Pagan Lagrangian Multiplier Test for Random Effects

I/K [Ticker, t] = Xb + u[Ticker] + e[Ticker, t]

Estimated Results:

	Var	sd-sqrt(Var)
I/K	.3194338	.5651848
e	.1724332	.4152508
u	0	0

Test: Var(u)=0

chibar2(01) = 0.00

Prob > chibar2 = 1.0000

Table A8. First Stage Instrumental Variables Regression for Leverage

	D/V (Log)
Financial frictions costs	-0.0489***
	(-8.57)
Adjustment costs	0.0178***
	-5.46
Constant	-1.986***
	(-38.49)
Observations	45552

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Table A9. Estimation Output for OLS, RE, and IV regressions

	I/K (sd of log)	I/K (sd of log) **(1)**	I/K (sd of log) **(2)**
S/K (sd of log)	0.0037***	0.0036	0.00259
	(2.58)	(1.05)	(1.91)
q (sd of log)	0.0008	-0.00013	0.0354*
	(0.08)	(-0.01)	(2.17)
IND	-0.00005	-0.00005	-0.00009
	(-0.19)	(-0.39)	(-0.35)
D/V (log)	-0.02143***	-0.0231***	
	(-10.14)	(-7.91)	
Q1	-0.0745***	-0.0746***	-0.0642***
	(-7.70)	(-4.29)	(-6.70)
Q2	0.0162	0.0160	-0.00925
	(1.68)	(1.02)	(-0.96)
Q3	0.0022	0.00216	0.000920
	(0.22)	(0.21)	(0.09)
sector1	-0.0678***	-0.0696***	-0.121***
	(-3.87)	(-5.32)	(-4.25)
sector2	-0.08115***	-0.0845	-0.203***
	(-4.63)	(-5.84)	(-5.31)
sector3	-0.07797***	-0.0798	-0.202***
	(-5.16)	(6.58)	(-6.17)
sector4	-0.0337	-0.0367**	-0.146***
	(-1.92)	(-2.65)	(-4.32)
sector5	-0.1351***	-0.140***	-0.288***
	(-8.00)	(-9.64)	(-6.21)
sector6	-0.08908***	-0.0924***	-0.200***
	(-6.00)	(-7.90)	(-5.61)
sector7	-0.12569***	-0.131***	-0.303***
	(-7.58)	(-9.77)	(-5.98)
sector8	-0.06744***	-0.0695*	-0.121**
	(-2.25)	(-2.36)	(-2.93)
D/V (1st lag of log)			-0.0864***
			(4.24)
_cons	0.0586***	0.0582***	0.0491**
	(4.24)	(4.56)	(2.71)
Observations	45878	45878	42628

t statistics in parentheses

* p<0.05, ** p<0.01, *** p<0.001

(1) – Clustered std. errors are used

(2) – Instrumental variable regression. Financial friction costs and adjustment costs are used as instruments for lagged leverage.

Table A10. Estimation Output for Arellano-Bond Dynamic Panel Model

	I/K (log)**(1)**	I/K (log)**(2)**
L.I_IK	0.0321*	-0.0850***
	-2.08	(-3.37)
L2.I_IK	-0.0452***	-0.124***
	(-3.59)	(-5.75)
L3.I_IK	-0.0520***	-0.123***
	(-4.16)	(-5.86)
L4.I_IK	0.823***	0.781***
	-56.49	-34.05
q (log)	-0.0612*	-0.0857*
	-2.17	-2.15
IND	-0.000172**	
	(-2.67)	
D/V (log)	-0.0504***	-0.0193
	(-4.07)	(-1.11)
S/K(log)	0.403***	0.228***
	(8.10)	(-4.81)
Ind_2		-0.00337
		(-0.09)
Shadow rate (log)		-0.0496***
		-4.72
_cons	-0.506**	-1.744***
	(-2.59)	(-5.33)
N	36719	15384

Z statistics in parentheses
*p<0.05,**< 0.01, ***<0.001

(1) – Std. Err. adjusted for clustering on Ticker. Instruments for differenced equation: GMM-type: L(2/5).log of I/K . Standard: 1st diff of Q (log), 1st diff of IND, 1st diff of D/V (log), 1st diff of S/K (log). Not differenced instruments: adjustment costs, financial frictions costs, quarterly dummy variables (Q1, Q2, Q3), industry dummy variables (Sector 1- Sector 8)

(2) – Std. Err. adjusted for clustering on Ticker. Instruments for differenced equation: GMM-type: L(2/5).log of I/K . Standard: 1st diff of Q (log), 1st diff of IND2, 1st diff of D/V (log), 1st diff of S/K (log), 1st of log of Shadow Rate. Not differenced instruments: adjustment costs, financial frictions costs, quarterly dummy variables (Q1, Q2, Q3), industry dummy variables (Sector 1- Sector 8)

Table A11. Arellano-Bond Test for Zero Autocorrelation in First-differences Errors

Order	z	Prob > z
1	-5.8049	0.0000
2	-.72775	0.4668
3	2.1891	0.0000
4	-9.3089	0.0000

H0: no autocorrelation